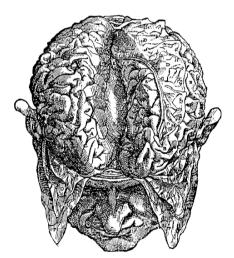
Göttingen Neurobiology Report 1996

Proceedings of the 24th Göttingen Neurobiology Conference 1996, Volume II

Edited by Norbert Elsner and Hans-Ulrich Schnitzler



1996 Georg Thieme Verlag Stuttgart · New York

Detection of spatio-temporal spike patterns by unsupervised synaptic delay learning

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If in certain brain regions the exact timing of axonal spikes is indeed the relevant parameter of neural signals, then the detection of spatio-temporal spike configurations appears fundamental for the processing of such signals. Therefore, we suggest the formation of spatio-temporal templates that is based on synapses with modifiable time delay. As a possible neural substrate, molecular messenger cascades are promising candidates for adjustable delays between *synaptic activation* (transmitter binding) and the onset of the postsynaptic potential (opening of the ion channels).

A template neuron carries synapses with delays τ_i that compensate the different arrival times of the EPSPs (evoked by the spike pattern) at a defined decision site. Our learning scheme requires a suprathreshold signal that is extracted from the depolarization u(t) at this site and that is available to the activated synapses whose delays change according to

$$\Delta \tau_i \sim \int_{T_{\mu}} \left[u(t) - \theta_{\text{learn}} \right] \cdot \lambda(t + t_i - \tau_i) \, \mathrm{d}t \, .$$

The learning function $\lambda(t) = -\frac{d}{dt} f\{EPSP(t)\}$, with an arbitrary but monotonously increasing function f, is derived from the EPSP and therefore, a synapse's learning function starts at the delayed onset of its EPSP. T_{μ} is an interval for which u(t) stays above a learning threshold θ_{learn} (see Figure), and t_i denotes the onset of the synaptic activation. If a spatio-temporal pattern of synaptic activation occurs sufficiently often, then a template is learned for synapses whose EPSPs initially have contributed to the suprathreshold signal. A neuron responds to its learned pattern with coincident EPSPs, i.e. with maximum depolarization, at the decision site.

